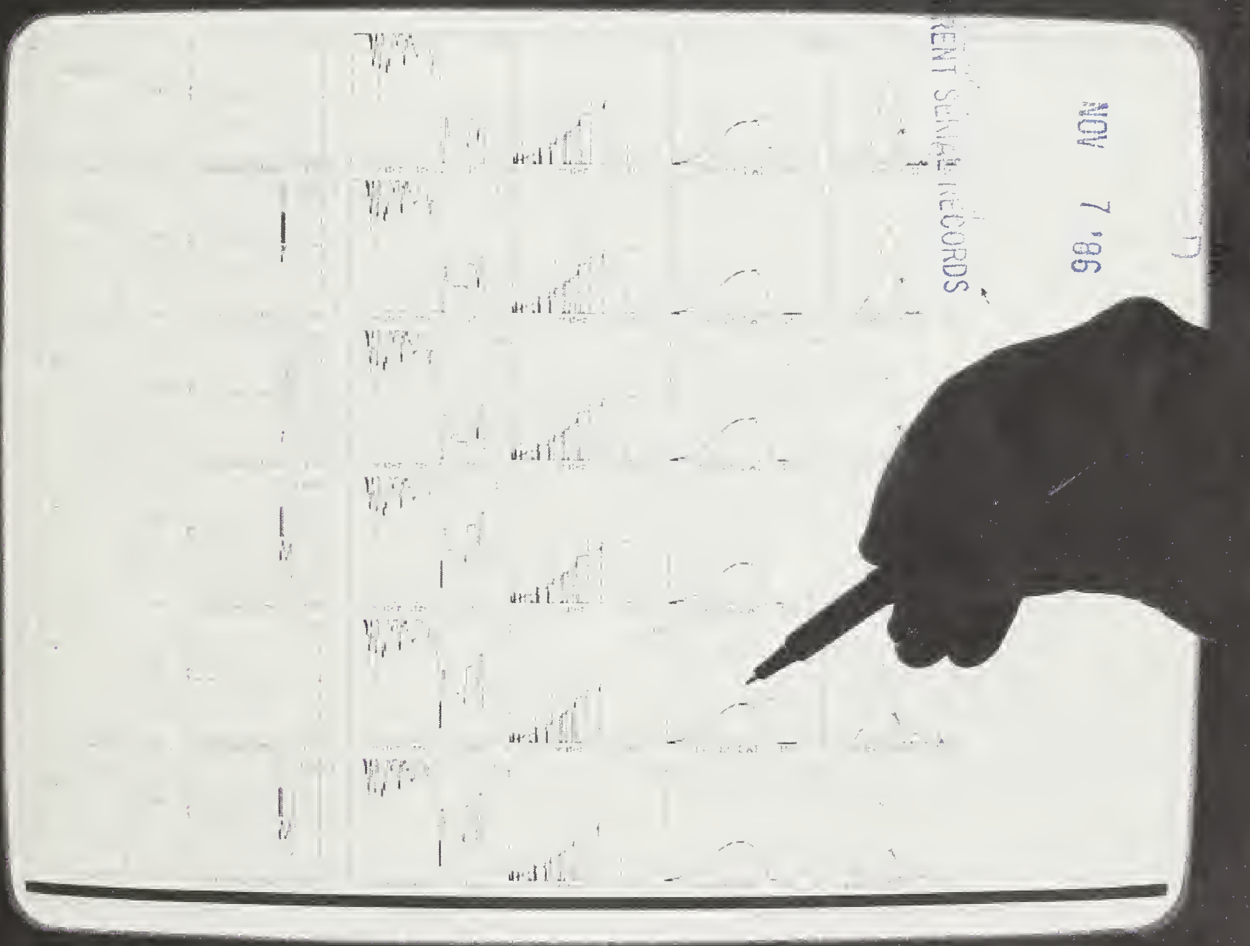
U.S. Department of Agriculture Agricultural Research Service Vol. 34, No. 8, September 1986

Agricultural Research



06/23/86 14:04:56 COTTON MANAGEMENT EXPERT SYSTEM:

APPLY 40 POUNDS OF NITROGEN ON JULY 23, IF IT STAYS HOT AND DRY.
HARVEST-AID CHEMICALS MAY BE APPLIED ON SEPTEMBER 1.
YOUR YIELD WILL BE 2.754 BALES PER ACRE.

The Great Cotton-Yield Mystery

There's something fascinating about cotton, a plant of persistent irony and a history seething with drama. It grew wild in both the Old World and the New, and it has been cultivated in both worlds since ancient times. It's a perennial but is cultivated as an annual. It's both a fiber and a food—cottonseed oil being the world's fifth most important edible oil and cottonseed meal a major feed for livestock. Cotton fiber was essential to the industrial revolution of northern Europe. Cotton figured as a major factor in the causes of the American Civil War that devastated the South, and it financed the South's economic recovery during Reconstruction. Invention of the cotton gin in 1793 made cotton the fiber of the masses.

From the end of World War II until the mid-1960's, the per acre productivity of cotton doubled in the United States, going from about half a bale per acre to a bale (a bale is about 500 pounds of cotton lint).

Then, mysteriously, while the yield per acre of virtually every crop in America was increasing by a percent or so annually, the yield of cotton not only failed to increase—it declined.

And yet there are at least a half dozen good reasons why cotton yields should have risen rather than fallen, especially: the introduction of higher yielding varieties, the elimination of poor quality cotton land from production, the squeezing out of weaker farmers by the economic crunch of low cotton prices, and better pest management.

Meanwhile, cotton has been subjected to overwhelming competition from synthetic fibers. Today, there are three bales of synthetics milled for every bale of cotton. Usage would be even more lopsided if it were not for the development, just after World War II, of a way to make cotton fabrics "wash and wear."

Agricultural Research Service scientists at the Southern Regional Research Center in New Orleans, LA, played a large role in that development as well as the latest improvement, known as durable press or permanent press. ARS scientists continue to search for ways to improve permanent-press treatments for cotton.

But people shopping for clothing always end up looking at the price tag. The synthetic fiber industry has recently adopted a vigorous strategy of research to produce fibers at still lower cost. For the cotton industry to survive, research to lower production costs is imperative. Yields are a good place to start, because if farmers can get more crop out of the same amount of land, with practically the same amount of inputs, the extra yield should increase net income.

One theory holds that the reason yields have declined is because cotton is so complex a plant it is particularly difficult to manage properly. Cotton has unique growing characteristics which are more complicated than those of most crops. For example, the cotton plant has only modest requirements for nitrogen during most of its growing season, but as it forms cotton bolls, the demand for nitrogen is intense.

If nitrogen is applied too early, or untimely rainfall occurs, the nitrogen may be leached from the soil before the plant needs it. If any nitrogen is left when the plant is finished making bolls, it will be used to grow taller plants with more leaves. Without additional cotton, this regrowth is nothing but a nuisance, interfering with the harvest.

Cotton management problems may be alleviated by an ARS-Mississippi State computer program that gives farmers expert advice. An industry group, The Cotton Foundation, is funding this work and also a study in which V.R. Reddy, an ARS plant physiologist at Mississippi State, will use the computer program to measure the roles various factors might play in the cotton yield mystery. Weather has already been eliminated as a cause. A computer comparison of weather patterns showed nothing that matches the decline in yields. Reddy will also look at air pollution in the form of ozone released from motor vehicle exhaust pipes and industrial smokestacks, soil compaction from heavy farm machinery, and management practices such as the rates and timing of herbicide and insecticide applications.

Perhaps part of the answer has been found unknowingly: U.S. Department of Agriculture estimates for 1984 and 1985 show record-high yields of 600 and 630 pounds per acre, respectively. No one is sure of the reason, just as no researcher has found a convincing reason for the prior years of decline.

But anyone who takes a look at how cotton yields have fluctuated over the past several decades can see that a great deal of effort by farmers and researchers working together will be needed to keep yields above 600 pounds per acre.

Hal E. Lemmon

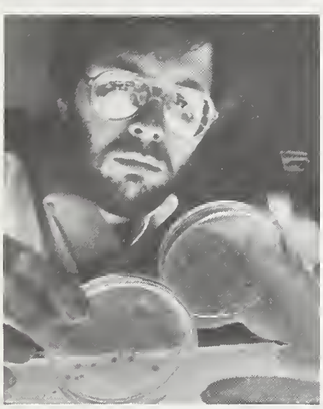
Crop Simulation Research Unit, Agricultural Research Service, Mississippi State, MS

Agricultural Research

Computer monitor shows crop data generated by a cotton management expert system developed by ARS scientists in cooperation with Mississippi State University. Each horizontal row shows predicted yield and harvest date with various applications of fertilizer and irrigation water. Story begins on page 6. (0786X800-13)

p. 9

p. 12



p. 14

Vol. 34, No. 8
September 1986

Editor: Lloyd E. McLaughlin
Associate Editor: Donald L. Comis
Photography Editor: Robert C. Bjork
Assistant Photography Editor: Anita Y. Daniels
Art Director: Deborah Taylor

Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, DC 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through March 31, 1987. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, DC 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

Magazine inquiries should be addressed to: The Editor, Information Staff, Room 318, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. Telephone: (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

Richard E. Lyng, Secretary
U.S. Department of Agriculture

Orville G. Bentley
Assistant Secretary
Science and Education

Terry B. Kinney, Jr.
Administrator
Agricultural Research Service

Grasshopper Virus: Possible Control Tactic

Viruses that naturally infect some grasshoppers might be used to stop the destructive rampages that grasshoppers often go on.

"We are searching for a natural plague that we can spread around before grasshopper outbreaks occur. This would prevent the severe crop and range damage that happens every few years," says John E. Henry, an Agricultural Research Service entomologist in Bozeman, MT.

Hot and dry conditions in the West can upset a delicate balance in which natural diseases keep grasshopper numbers fairly stable. Grasshoppers thrive in dry weather and can reproduce faster than their natural diseases can infect them.

"During a typical grasshopper outbreak, six to 10 grasshopper types predominate. Each is slightly different and reacts to viruses in different ways.

Grasshopper feeds on wheat plant. Every few years, hot and dry weather in the West triggers grasshopper outbreaks that severely damage crops. (0779X981-18A)

Henry says an ideal virus, once introduced into the grasshopper population, would continue to infect later generations, perhaps requiring only one control effort that would last several years.

Because he hasn't found any sufficiently virulent viruses among the more than 600 grasshopper species in this country, he is now sorting and classifying those he has collected worldwide.

"Seven entomopox viruses look promising," he says. "They cause diseases in grasshoppers but not humans or livestock."

Henry says so far he has tested one entomopox virus on a 10-acre test plot and found results encouraging.

Chemical controls are quicker but can be expensive. "The 1985 infestation cost the federal government more than $26 million. We can expect the total bill, including state and private costs, to have been double that," says Henry.—By **Dennis Senft,** ARS.

John E. Henry is at the USDA-ARS Rangeland Insects Laboratory, Montana State University, South 11th Ave., Bozeman, MT 59717. ■

Pollen Put in Deep Freeze

Most people associate pollen with springtime wheezing and sneezing, but it is an essential element in the propagation of most types of plants, including food and feed grains.

And now researchers at USDA's Agricultural Research Service are chilling pollen from a protein-rich grain to give it a longer life than nature planned.

Normally, the pollen from pearl millet dies a few hours after being removed from the plant's flowers. But Wayne W. Hanna and two coresearchers at Tifton, GA, have kept the pollen alive in cold storage for over 4 years.

Hanna says storing pearl millet pollen longer saves the time and space needed to grow plants for pollen.

"It's like having a sperm bank to draw from to breed better varieties of pearl millet," says Hanna, a plant geneticist.

"Whenever we need pollen to fertilize other plants, we have a ready supply in the refrigerator or freezer," he says. "Before, we had to continually grow many plants for no reason other than having their pollen, and that was time-consuming and expensive."

Unfamiliar to most Americans, pearl millet is a plant of many uses, ranking among the world's important human staples and animal feeds. According to Hanna, it is grown as a food grain on 50 million acres in India and Africa. In Australia, South America, and the southern United States, it is a major summer livestock forage.

Because it tolerates drought better than other grains, U.S. ranchers increasingly see it as a potential feed grain in areas where irrigation water is neither as plentiful nor as cheap as it once was.

Hanna, geneticist Glenn W. Burton, and agronomist Warren G. Monson developed the pollen-storage technique.

In the new technique, pollen is harvested, dried, and stored in airtight containers. Best results were obtained by drying pollen to 6 or 7 percent moisture or less and storing it in a refrigerator at 40°F or in a freezer at 0°F.

Pollen with higher moisture of 7 to 8 percent has been preserved at -100°F, but that requires a special freezer.

Hanna says, "We hope that scientists working with other kinds of grass will find our techniques applicable, perhaps with modifications, to their breeding programs."—By **Sean Adams,** ARS.

Wayne W. Hanna, Glenn W. Burton, and Warren G. Monson are at the USDA-ARS Forage and Turf Research Laboratory, Georgia Coastal Plain Experiment Station, Tifton, GA 31793. ■

Tomato Product Repels Grain Weevils

A natural product of the tomato plant may protect stored grain against some insects.

Chemist Karl J. Kramer and entomologist Richard W. Beeman, both with the Agricultural Research Service in Manhattan, KS, are testing 2-tridecanone, a chemical taken from the foliage of tomato plants. In one test, they applied various doses to wheat and then infested the wheat with eight species of stored-product insects.

The natural insecticide was most effective on granary, rice, and maize weevils—insects which insert their eggs into the grain kernel. It was not effective, however, on the other insects tested—the confused flour beetle, the red flour beetle, the lesser grain borer, the Indianmeal moth, and the almond moth. These insects place their eggs on the surface of the grain. "2-Tridecanone probably penetrates the wheat kernel, where it is more effective against insects that develop internally," says Kramer.

Kramer placed granary weevil eggs in jars of untreated wheat and in wheat treated with 200 parts per million 2-tridecanone. After 12 weeks, an average of only two young weevils developed per jar of treated wheat, as compared with an average of 357 weevils in each jar containing untreated wheat.

2-Tridecanone also proved to be a weevil repellant. In jars of both treated and untreated wheat, granary weevils could "escape" by crawling into probe traps. After 183 hours, half the weevils were trapped in untreated wheat, while only 18 hours elapsed before 50 percent crawled into the probes in wheat treated with 500 parts per million 2-tridecanone.

The chemical first came to Kramer's attention when George Kennedy, an entomologist at North Carolina State University, reported in 1980 that it was toxic to certain plant-eating insects. It is but one of several possible new treatments for stored grain that Kramer is testing.—By **Linda Cooke-Stinson,** ARS.

Karl J. Kramer is in USDA-ARS Biological Research at the U.S. Grain Marketing Research Laboratory, 1515 College Avenue, Manhattan, KS 66502.

Iron and Aging: A Look at Ferritin

Research at ARS' Human Nutrition Research Center on Aging at Tufts is probing one theory of aging and turning up some intriguing findings. This widely studied theory holds that aging is due to the oxidation of cell membranes—the gatekeepers and structural framework of cells.

One cause of oxidation, says Hamish Munro, senior scientist at the Boston center, may be too much free iron in the body's cells. Although iron is an essential mineral, an excess could lead to the destruction of cell membranes by oxidizing their fatty components. Normally, cells protect themselves by producing ferritin—a protein that locks up the iron until it is needed.

The theory is far from ironclad, however. Munro and colleagues want to determine if the aging process is accelerated or controlled by iron that isn't locked up in ferritin. One question, he says, is whether "as we get older our capacity to make ferritin decreases, or does ferritin cease to do its job properly?"

Munro and colleagues at the Boston center have cloned the gene that contains the blueprint for ferritin. They found that ferritin is composed of 24 subunits that come together to form a shape "like a practice golf ball," he says. Free iron passes through the holes and is trapped inside.

While working with a team from the Massachusetts Institute of Technology, Munro discovered that although the gene dispatches the message to assemble ferritin, the messenger "sits around until it is called into action by iron." The

Hamish Munro, senior scientist at the USDA-ARS Human Nutrition Research Center on Aging at Tufts University in Boston, MA. (1082X1209-3)

messenger is RNA copied from the code in the DNA. There are only a few instances known in which messenger RNA is latent, Munro says. "This is the first one found to be activated by a known signal."

Iron activates messenger RNA to assemble ferritin, and Munro believes his team has clues to the identity of the segment of the messenger RNA that acts as the switch. The segment is located near the start of the code for ferritin, he says, "just where you'd expect to find a regulator."

To confirm that the segment is the switch, Munro is making artificial segments in the lab and attaching them to messenger RNA's for other proteins. If iron activates the production of these proteins, he says, "we will know that the segment is indeed sensitive to iron."

With the ferritin machinery virtually decoded, Munro says he is feeding iron-rich diets to laboratory animals to see if their ferritin production keeps pace with the toxic levels of iron as they age.—By **Judy McBride,** ARS.

Hamish Munro is at the USDA-ARS Human Nutrition Research Center on Aging, 711 Washington Street, Boston, MA 02111. ■

When Comax Speaks, Farmers Listen

Above: Donald Baker, Crop Simulation Research staff leader (right), and Hal Lemmon, computer scientist, look at Comax-generated graphs on the screen of the Symbolics 3670 computer, which Lemmon used to write the Comax program. (0786X798-14)

Facing page: Plant physiologist V.R. Reddy measures cotton plant growth before putting the plants into computerized growth chambers to begin a 2-year project in which he will collect data on the effects of a commonly used cotton growth regulator. Data will be fed into Comax to expand its scope. (0786X789-18)

Mississippi cotton farmer Frank M. Mitchener lost hundreds of thousands of dollars worth of cotton in a bet against a computer 2 years ago, but he won't let it happen again.

In 1984, Mitchener, who farms several thousand acres of Mississippi Delta cotton land in Sumner, MS, began testing a computer model that predicts cotton yields. USDA's Agricultural Research Service conducted the test in cooperation with the National Cotton Council. The model is called Gossym, a hybrid term formed by combining *Gossypium,* the plant genus cotton belongs to, with "simulation."

Mitchener had scheduled a family vacation for the first 2 weeks in September, a time he decided would be that coveted pause before a hectic harvest. Like other cotton farmers, he made his decision on when to harvest by a 60-percent boll-open rule of thumb.

Cotton bolls are the fruit of the plant that contain the seeds with their attached cotton lint. To tell when the cotton is mature enough to harvest, farmers look at sample plants and count how many bolls have dried and cracked open.

When they find that at least 60 percent have opened, they prepare for harvest. This involves applying chemicals that stop growth, pop bolls open, and cause leaves to fall off, allowing the mechanical pickers easy access to the bolls. Then the race to harvest begins. The pressure is on because the fall brings rain that can turn fields into Mississippi mud traps, knock cotton out of the bolls, lower cotton weight by washing the wax off, and create moist homes for fungi that weaken and change the cotton to a less valuable off-white color.

What Mitchener would like to have is more time to harvest before the rains come. And that's what the computer tried to tell him he had...the computer told him to spray his defoliants on September 1 and begin harvesting. Mitchener was darned if a computer was going to defy the 60-percent rule and ruin his vacation plans too.

Mitchener returned from vacation on September 14 and began defoliating

on September 21, the day after he counted 60 percent of the bolls cracked open on several plants. He started harvesting 10 days later.

He got only 675 acres harvested before the rains began on October 6. "Twenty inches of rain fell in October with little cotton harvested again until November," Mitchener says. "Had I listened to the computer and started on September 1, I could have begun harvesting on September 13 and been finished before October 6. Normally, I harvest 1,100 pounds an acre of good quality cotton. As it turned out, I lost about 200 pounds per acre (that fell to the ground) and probably 12 cents a pound in quality."

"We learned how important the ability to predict mature bolls is to cotton farmers."

—**James M. McKinion,** crop simulation researcher

Cotton experts had long known that cotton bolls are mature 2 or 3 weeks before they're dry enough to crack open, but they never knew a farmer's livelihood depended so heavily on that knowledge. "That's one benefit of us working so closely with farmers on a program like this: We learned how important the ability to predict mature bolls is to cotton farmers," says James M. McKinion, an electronics engineer who is part of the ARS Crop Simulation Research team at Mississippi State University. "That turned out to be the biggest value of the program to Mitchener."

Mitchener's computer is linked by telephone line to a solar- and battery-powered weather station in one of his fields. The weather station collects information on air temperature, rainfall, and solar radiation.

The computer model's intimate knowledge of the daily lives of cotton plants came from data collected since 1974 in bubble-top containers developed in South Carolina in collaboration with Clemson University. Now located at Mississippi State, these outdoor chambers are wired to computers inside the research buildings. The computers sense and control the temperature, soil moisture, and carbon dioxide concentration in the chamber's atmosphere.

The scientists made daily observations of the plants growing in the chambers. They fed this data into the computers, along with measurements taken by removing some plants and analyzing them for weight and contents.

To tailor the model for each farm, the scientists need only add specific soil data and the varieties that will be planted. Then the weather station becomes the driving force for the model, giving it the daily information it needs to make predictions based on past experience.

Owning a $5,000 weather station isn't essential. If the model is ever widely used, some farmers may decide to share a weather station centrally located at the local cotton gin. By necessity these farmers already cluster in "gin communities" no more than 15 miles from a gin so, except for rainfall data, the weather information should be applicable to their farms.

But in 1984, the year Mitchener and Sam McCoy, a South Carolina cotton farmer, began the test—sponsored by Union Carbide Corp. through the National Cotton Council—even one gin community would have been more than McKinion and his colleagues could have handled. As McKinion puts it, "We had our hands full helping two farmers run and interpret this complex research model. We're just 7 scientists and 3 technicians, and we can't work that closely with even a fraction of the nation's 30,000 cotton farmers."

This team—which developed the latest version of the model over a 12-year period, from 1973 to 1984, in cooperation with Mississippi State University, Clemson University, and the Hebrew University of Jerusalem, Israel—knew that help was in sight because they had been chosen as one of three ARS teams to test the application of a $120,000 Symbolics 3670 computer to agricultural problems. The other teams are at Cornell University in Ithaca, NY, and at the ARS center in Beltsville, MD.

The Symbolics 3670 had recently entered the marketplace as a smaller and less expensive version of the multimillion dollar supercomputers used with artificial intelligence systems in military, aerospace, and university research. Unlike the typical personal computer, it deals with words and other symbols, rather than numbers.

This new tool gave Hal E. Lemmon, a scientist on the Crop Simulation

Research team, the power to write a computer program that mimics the thinking of human experts when restricted to a limited area of knowledge. And he did it in 7 months.

The program, called Comax (COtton MAnagement eXpert), runs Gossym for the farmer and takes the place of scientists in interpreting the numerical data churned out by the model.

The great thing about this program is that although it was written on a $120,000 machine, it can be copied onto a diskette and used on the current generation of IBM personal computer, the PC-AT, or equivalent machine, beefed up with extra memory. At today's prices, users would pay $4,000 to $7,000 for the computer and related equipment. Of course, by the time this program is ready for commercial use, even more powerful machines may be available at the same price.

The expert system developed at Mississippi State revolves around a set of "If-Then" rules such as: "If the crop suffered stress from nitrogen

Mitchener (left) and McKinion check automated weather station which feeds daily weather information into Mitchener's farm computer to be used to update its cotton yield and harvest date predictions. (0786X791-28)

deprivation on July 20 in the last simulation, then see what happens if 40 pounds of nitrogen were to be applied on July 10." The computer keeps trying different amounts and dates to see which will prevent a yield-robbing nitrogen stress. When it finds the best combination to prevent this, it recommends that action to the farmer.

During the 1985 season, the crop simulation team used Comax/Gossym on their computers and gave Mitchener and McCoy the results. The farmers had only the cotton growth model, without the expert system to run the model for them.

The 1986 season is a different story. Both have a version of Comax that runs on their computers. And 20 other cotton farmers from across the Cotton Belt, including Mitchener's neighbor Kenneth B. Hood, have joined the test.

Hood's cotton season has gotten off to a different start this year because of the program. Take June 10, for example. That's the date he used to routinely apply nitrogen fertilizer at the rate of 50 pounds per acre. Not this year.

At 3:30 that morning, Hood was in his office, centrally located on the land he and his brothers farm, asking his computer to call the weather station and update its files to include a heavy rainstorm that happened the previous day. Hood leaves the computer running 24 hours a day and can add the previous day's weather to the files after midnight each day.

Hood wants to know how the 2 inches of rain will affect the nitrogen fertilizer he applied before planting in April. Will it wash so much of it away that his plants will go into nitrogen stress soon? Will he need to apply more, how much, when?

The computer asks him if he wants to simulate an entire growing season, starting from the date of emergence of the cotton he planted on April 7, or later. Hood types in June 10. The computer monitor's screen shows several optional weather scenarios for the rest of the season. Hood chooses to assume the weather will be mainly hot and dry.

The computer tells Hood he's in good shape. He won't need to apply any more fertilizer for over a month if the weather does stay hot and dry. That answer is backed by a graph showing his plants won't need more nitrogen until July 23. The computer also prints five other graphs showing: past nitrogen applications, rainfall, predicted water stress, plant growth (height, number of flower buds, number of bolls), and predicted yields. All of the graphs, except for the one with yields, show the plants' responses on a daily basis throughout the normal 160-day growing season.

"Before this, it was all guesswork and habit. I'd automatically apply 50 pounds of nitrogen every June 10, without knowing when or how much was actually needed. With cotton prices at 55 cents a pound and promising to get lower, we need to take some of the guesswork out or we'll all be out of business. It'll make us better farmers, help us make better, more timely decisions. That's the name of the game. I'm trying this on 600 acres of the DPL 50 cotton variety and 200 acres of Acala 90. If it works, I'll use it on my entire farm next year," Hood says.

Hood is carefully examining his cotton, recording details such as the

number of flower buds. He needs this data to be sure the plants in the field look the same as the plant image in the computer. For each cotton variety, the computer, on a daily basis, can draw a picture of the cotton plant to show how it sees the plant developing.

Graphs Replace Mind-Boggling Numbers

The ability of the computer to print information in the form of graphs, in addition to words, is a very important part of Comax. Information, such as the period when the plant will undergo stress, stands out at a glance, a far cry from what was available in 1984. Back then, Mitchener got the model's calculations in "a series of columns of hundreds of numbers, more than the brain could comprehend."

And the time it took Mitchener to run the model himself limited its usefulness to him. "It took from 1½ to 2 hours to run a simulation. And you had to simulate the entire season every time you changed something. When I tried to consider different alternatives—playing what I call the 'What-If' game—I couldn't afford to try too many variables. To save time, I made decisions without considering everything."

Comax makes the runs for farmers, playing the "What-If" game for them, while they sleep.

When run on an IBM PC-AT or equivalent personal computer, it can simulate an entire season in 20 to 30 minutes. As it tries different scenarios, it can save even more time by restarting later in the simulated season, from the date of the latest change.

Farmers can ask for an explanation of how the computer arrived at its decision, so they can judge its wisdom.

This ability to explain itself gives Mitchener and other farmers confidence in the computer. Had the model been smart enough to defend its recommendation for an early harvest in 1984, Mitchener says he would have listened to it.

By last year, Mitchener was more of a believer, so much so that when the computer told him to break another longstanding rule of cotton farming he did it almost without blinking and he did it on every one of his several thousand acres instead of just the test plot.

That season the computer told him to apply 30 pounds of nitrogen fertilizer in late July. Cotton farmers worry about fertilizing after June 30 because they know it might cause a regrowth. Mitchener sometimes applies fertilizer early in July, but never later on, so close to the time he intends to apply defoliants and boll-openers to stop plant growth.

Comax tells cotton farmers when the plants are mature enough to harvest. (067-7-36)

The cotton model predicted that Mitchener's plants would go into nitrogen stress in August if he didn't apply nitrogen in mid-July.

The model can anticipate nitrogen stress long before it occurs and causes visible damage. "I would never have seen that my cotton needed more fertilizer until August, and then it would have been too late to put it on," Mitchener says.

Mitchener may be a believer but he can't afford to be a blind follower. He hedged his bets a little, cutting the recommendation down to 20 pounds per acre for his farm. He did apply the recommended 30 pounds to half of the 16 rows in his test plot, leaving every other row unfertilized, for comparison. The eight fertilized test rows yielded $60 more cotton per acre, after costs, than the unfertilized rows.

The computer may very well have been correct about the plants being able to use 30 pounds of nitrogen per acre, but the increase in yield may not have been enough to justify the expense and risk of applying that much fertilizer.

Mitchener examines cotton plants to see if they are developing at the pace predicted by Comax, the computer program he is testing. (0786X805-7)

Mitchener had already applied a total of 140 pounds per acre to his fields and he couldn't accept the risk of raising that to 170, so much more than he had ever applied.

To make sure the recommendations are cost-effective, the crop simulation researchers are adding a computerized economics package that will calculate the costs of fertilizers and other inputs and compare them to the value of the yield.

At his farm office in Sumner, MS, Frank Mitchener (center) looks over data from the Comax (COtton MAnagement eXpert) computer program with James McKinion, an ARS electronics engineer. Mitchener's assistant, Mylinda Cail, prepares to enter instructions for Comax. (0786X793-20)

Besides information on nitrogen applications and harvest dates, the computer program also gives advice on irrigation. And it considers all these decisions in combination, accounting for interactions that affect yields.

Just as the computer anticipated nitrogen stress for Mitchener, it can anticipate water deprivation before any wilting is visible. Farmers will know weeks ahead of time that if there isn't a rain, the plants will start suffering damage on a certain day. In the past, a farmer would see the plants begin to wilt and then decide to turn the irrigation pumps on. Typically, the decision would be made one day and irrigation start the next.

For those who irrigate, McKinion envisions a day when Comax will not only make recommendations but actually carry them out. "It can be used to turn irrigation systems on and off whenever it decides. In addition, it could operate equipment that will mix herbicides, insecticides, and other chemicals into the irrigation water, deciding what, when, and how much to add."

The crop simulation team plans to expand Comax to include many other features, including models for the control of insects, weeds, and diseases. Entomologist Robert E. Fye has already begun developing the insects model, which will give farmers recommendations on insecticide applications.

Fye is collecting data on a dozen major insect pests and beneficial insects raised in eight computerized chambers. Currently, he is studying bollworms, a lygus bug, and a spotted mite. This summer he is feeding them bits of cotton plants to see how much and how fast the insects eat.

He is also finding out how quickly the insects develop at different temperatures. When all this information is in the computers, farmers can use it to know when and if to spray or whether they will have enough beneficial insects to do the job.

The National Cotton Council, a nonprofit association which represents the entire cotton industry from farm to textile mill, has investigated the possibility of starting a computerized telecommunications network that, as an extra benefit, would make Comax available to any Cotton Council member. The network would enable farmers to communicate by electronic mail with everybody else in the cotton business, as well as government agencies such as USDA's Agricultural Stabilization and Conservation Service.

A 1984 survey by the Cotton Council showed that 23 percent of their cotton farmers had computers, most with telephone linkups. The Council estimates that the share of member farmers with computers rose to a third in 1985.

Andrew G. Jordan, Director of Technical Services for The Cotton Foundation, a sister association of the Cotton Council, says the Council and the Foundation will begin a pilot test of the electronic mail network in September 1986, with participants from "every area of the Cotton Belt."

Jordan is very excited by both the network and Comax. He compares the possible dramatic changes in cotton farming with the types of changes Cyrus H. McCormick's reaper brought to wheat farmers and the tractor brought to all farmers.

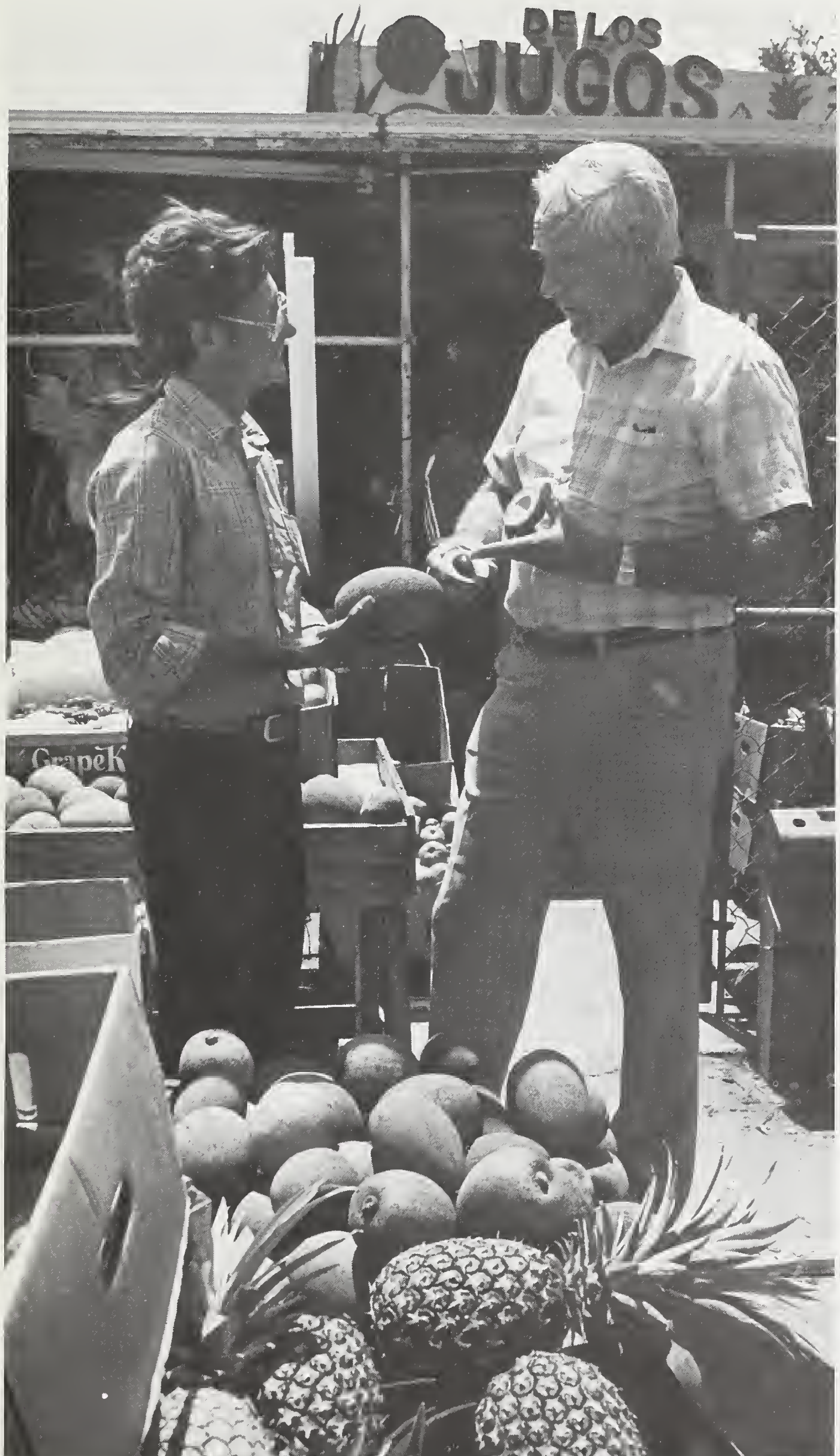
But Jordan is a level-headed businessman, and he balances the excitement with caveats about Comax. "Anything this new and exciting gets a lot of hype. We chose to spend more than $500,000 in aid to this project because we saw it as something useful that needed a financial boost to get it off the research workbench and onto the farm. We think it will allow farmers to make better decisions. But it's still just one more tool to help make farmers more competitive in the world market. We're not recommending farmers follow it blindly."

Nor would Baker. "The model Comax uses is more than 12 years old. Parts of it need updating. New cotton varieties have come on the scene, along with new compounds for cotton growers—such as new harvest-aid chemicals. Also, we need to expand Comax to respond to insect damage. There's a great deal that needs to be done over the next few years.

"On the other hand, we've seen that growers can reap some economic benefits from it right now. Despite the fact that we've got a lot of work left to do on it, we're already beginning to see some payoffs."—By **Don Comis,** ARS.

Donald N. Baker, Hal E. Lemmon, and James M. McKinion are in USDA-ARS Crop Simulation Research, P.O. Box 5367, Mississippi State, MS 39762. ■

Strange Names, Fancy Flavors



Horticulturist Robert Knight discusses fine points of mamey, a Cuban fruit, with employee of roadside fruit stand in Miami. (0786X884-7)

Exotic fruits with names like mamey, carambola, and lychee may someday become everyday items in your neighborhood grocer's produce section, thanks to Agricultural Research Service scientists at Miami, FL.

Indeed, who could resist a fruit like the carambola, a member of the wood sorrel family, whose sides are so deeply indented that it slices into sections resembling five-pointed stars? Besides its eye-catching shape and mild flavor, the carambola is attractive for nutritional reasons: It's a good source of vitamins A and C.

ARS horticulturist Robert J. Knight believes it has a bright future with consumers. He says, "I can see carambola really catching on in this country, because it's tasty and fairly adaptable to our climate, so it's easy to grow here."

"I can see carambola really catching on in this country, because it's tasty and fairly adaptable to our climate."

—Horticulturist **Robert J. Knight**

In fact, growers in Florida are devoting more and more of their land to carambola orchards. "Right now, we probably have about three times more acreage in carambola than we had just a few years ago," says Knight. "Plus, there are a great many areas in Florida which have just been planted, and those trees should begin to produce within 3 to 5 years."

Unlike most fruits, which have only one season, the carambola produces fruit twice and sometimes three times in a single year.

Knight attributes the growing popularity of some subtropical and tropical fruit partially to an increase in the immigrant population; for example, Southeast Asians in California and Latin Americans in south Florida. Tropical fruit is often an important and familiar part of their traditional cuisine. Mamey, for instance, a large ruddy fruit which tastes somewhat like sweet

potato, is considered the national fruit of Cuba. And the lychee, a bright red sweet fruit about the size of a plum, has long been popular with the Chinese.

These are but a few of the many subtropical and tropical fruit crops being studied by Knight and other scientists at the USDA-ARS Subtropical Horticulture Research Station.

The first step in finding a new fruit crop is finding and importing the germplasm. Germplasm is the living cellular material containing the genetic blueprint of chromosomes for that particular plant. Knight's germplasm samples may be bits of plant tissue, seeds, or whatever is available.

When considering a new fruit, Knight asks: Is this fruit any better than the varieties we now have? Does it produce fruit well and regularly? Is it nutritious? Can it be economically grown here?

Candidates for U.S. crops are first evaluated for their ability to adapt to the southern United States. They are exposed to freezing temperatures, insects and disease, and adverse soil conditions. Knight next grows a large seedling population using the hardiest samples and then crossbreeds among these plants to develop new varieties.

Says Knight, "One thing we must always keep in mind: Horticulture is a matter of working with the environment. Plants are genetically programmed to respond to certain environmental conditions, and they must have those conditions for the most favorable growth. The best that we can hope for is to modify some plants so that they can be grown over a larger area—however, this certainly doesn't work with every plant."

Often, a fruit can be improved by crossing two members of the same family. A classic example is the atemoya. In 1907, P.J. Wester of USDA, who was stationed in Miami for many years, was working on improving the cherimoya, a fruit usually grown in Peru, Chile, Bolivia, and Ecuador.

The cherimoya, one member of the family collectively called the "custard apple," and related to the American pawpaw, is a large green fruit with sweet, aromatic pulp and smooth, dark seeds. Since the cherimoya would ordinarily be grown in the mountains, it wasn't too successfully produced in Florida. Its poor relation, the sugar-apple, or anon, was better adapted to warm, sea-level conditions but was smaller and not as pleasantly aromatic.

So Wester crossed the cherimoya with the sugar-apple and came up with the atemoya, which grows very well at sea level, has a lot of vigor, and produces delicious fruit.

Wester's atemoya was the first of its kind; since then, even better varieties of the hybrid have been developed.

"We're hoping to produce a passion fruit which can be grown as far north as Virginia and Maryland."

—Horticulturist **Robert J. Knight**

Port of Entry for New Crops

USDA's Subtropical Horticulture Research Station at Miami, FL, is one of eight stations where plants from all over the world are evaluated in search of new crops for the United States. First established in 1898 on 6 acres of land, the station has since grown to 210 acres, and over 20,000 plant introductions have been cataloged.

The station houses the Clonal Germplasm Repository, a collection of about 8,500 tropical and subtropical fruit, nut, and ornamental plants. Under the direction of curator Edward J. Garvey, plant material is provided to researchers, botanical gardeners, and commercial nurseries. Since 1933, when records were started there, more than 87,000 requests for plant material have been filled.

This is also the National Clonal Germplasm Repository for mangoes, coffee, avocados, bananas, plantains (a banana relative), subtropical jujubes (a date-like fruit), and sugarcane—which means the station is responsible for maintaining samples of up to 250 varieties of each crop, plus wild species.—C.L. ■

Top: Marc Ellenby of J.R. Brooks and Sons examines an atemoya in his private orchard. This hybrid of the cherimoya and anon (sugar-apple) was originally developed by ARS. (0786X896-10)

Center: Bright red lychee fruit originated in Southeast Asia but is gaining popularity in the southern United States. (0786X886-6)

Bottom: Two varieties of star-shaped carambola being developed by ARS. Plumper fruit with shorter "spikes" is better suited for shipping. (0786X883-21A)

Packers prepare carambola for shipping at J.R. Brooks and Sons, a Florida-based fruit grower and distributor. (0786X898-6)

Many improved fruits have been developed at the Subtropical Horticulture Research Station since Wester's atemoya. Some are still in the testing stage, such as a new passion fruit which is a cross between the yellow and purple tropical variety from Brazil and a subtropical variety from Maryland. "The hybrids we produced are more resistant to cold—a characteristic they get from the Maryland species—because of their ability to form new shoots from underground roots or rhizomes. But they still lack the superior fruit of the Brazilian species," says Knight.

"We're hoping to produce a passion fruit which can be grown as far north as Virginia and Maryland and still have the high quality and flavor of the Brazilian species."

Why are consumers still finding that many tropical fruits are expensive?

According to William C. Schaefer, marketing director for J.R. Brooks and Sons, a Florida-based fruit grower and shipper, it's partly because tropical fruit requires extra special care to keep it fresh and damage-free. Says Schaefer, "We use a lot of hand labor to prepare the fruit for shipping—treating it to prevent spoilage, using special packing materials—whatever's necessary for the fruit to arrive at peak quality." Besides the high labor costs, the rarer tropical fruits like lychee and mamey are still grown in relatively small quantities, which makes them something of a novelty in grocery stores.

William H. Krome, a Dade County fruit grower who bought his first avocado grove in 1929, agrees that some of the low-volume fruits can turn out to be moneymakers.

Krome specializes in avocados and limes but says mangoes provide the best return right now. He has also planted a few trees of lychee and mamey, "just to see how well they do."

Krome feels that the tropical fruit industry will continue to grow in this country as more and more people become aware of the variety of fruits available.

Educating consumers about the new fruits is one of Schaefer's biggest tasks. He says that J.R. Brooks and Sons uses a number of avenues for publicity, including advertising, news releases, visits to food editors, and in-store demonstrations. They send trained personnel into supermarkets to give out free samples of fruit, armed with nutrition information, recipes, growing tips, and so forth. "The in-store demos are relatively productive," says Schaefer. "They're a good way to get people to try different fruits."

"The bottom line," says Knight, "is to broaden the base of U.S. agriculture, by breeding new plants and improving the varieties we already have; to cooperate with U.S.-sponsored agricultural programs, such as exchanges of plant material and technical information with various foreign countries; and ultimately to offer American consumers a wider range of food choices."—By **Caree Lawrence,** ARS.

Robert J. Knight is at the USDA-ARS Subtropical Horticulture Research Station, 13601 Old Cutler Road, Miami, FL 33158. ■

Genes Found to Help Bacteria "Eat" Pesticides

Microbiologist Jeffrey Karns checks petri dishes in which he grows pesticide-degrading bacteria. (0386X501-35)

Two soil bacteria have been found that can be genetically altered to help speed the breakdown of pesticides, says microbiologist Jeffrey S. Karns of the Agricultural Research Service.

"We have identified genes that cause enzymes to degrade certain pesticides," says Karns. "Now, we are cloning the genes so that the bacteria make a lot more enzymes for better toxic waste disposal, especially on farms."

Agency research on pesticide-degrading bacteria is aimed toward an environmentally sound way to dispose of pesticides.

One of the bacteria in Karns' studies, *Achromobacter,* fully degrades carbofuran, a pesticide used against corn rootworm and other crop insects, in a matter of hours. Another, *Flavobacterium,* partially degrades coumaphos, used to kill insect pests of livestock, in about 36 hours. Complete degradation takes another day of treatment using ultraviolet light and ozone.

"These are potent insecticides. The bacteria can substantially reduce their presence on farms by degrading them quickly, before they can seep into the soil," Karns says.

Farmers commonly dispose of excess pesticides from spray tanks in soil pits that are lined with concrete or plastic. Microbes in the pits at least partially degrade the wastes to less toxic materials. However, the process is slow—taking from several weeks to a year—and leaking pits can allow liquids to seep into groundwater.

Karns and his colleagues at the ARS laboratory in Beltsville, MD, will continue to search for other pesticide-eating bacteria that can be genetically engineered to hasten the decomposing of pesticides.

Karns uses a DNA-cloning technique to isolate the genes from the bacteria. He first inserts the enzyme-making genes into plasmids, which are free-floating, replicating circles of DNA in bacteria. Then, he chemically cuts the plasmid, splices in the gene he wants to study, and tests the new gene for the ability to break down a pesticide.—By **Dvora Aksler,** ARS.

Jeffrey S. Karns is at the USDA-ARS Pesticide Degradation Laboratory, Bldg. 050, Beltsville Agricultural Research Center, Beltsville, MD 20705. ■

TEKTRAN Offers Preview of ARS Research

Over 6,000 brief, easy to read summaries of the latest research on genetic engineering, safeguarding crops and animals from diseases, biological control of pests, human nutrition, and other fields are available on a new computer information service provided by USDA's Agricultural Research Service.

Known as TEKTRAN, for *Technology Transfer Automated Retrieval System,* it offers notice of research results which have been peer-reviewed and cleared by ARS management. About 300 new findings are entered into the database each month.

ARS is offering—on a first-come, first-served basis—an opportunity for a limited number of interested organizations with computers and telephone modems to have direct access to TEKTRAN. There is no cost for using the database. However, users are responsible for their own telephone charges.

Each entry on the database includes a brief summary describing the research but does not reveal specific details that would preclude patenting or publication. TEKTRAN also provides the name, address, and phone number of ARS scientists involved in the research.

Computer searches can be made in several categories. Among these are: Keyword, Multiple Keywords, Scientist's Name, and Commodity. The file can be accessed by specific dates in addition to the search categories indicated above. A user could enter the system once a month, for example, to search for new entries on a specific topic without having to look at the entire database each time.

Additional information on the procedure necessary to obtain access to this new database can be obtained by contacting: *James T. Hall, National Technology Transfer Coordinator, USDA-ARS, Room 403, Building 005, BARC-West, Beltsville, MD 20705. Telephone (301) 344-4045.* ■

Unshelled Walnuts OK for Export to Japan

U.S. walnuts still in the shell can be sold to Japan, now that USDA Agricultural Research Service scientists have found a way to keep the nuts free of codling moths.

Japan does not have the codling moth and has been quarantining walnuts and certain other products that might bring the pest into the country from the United States and other foreign countries. The codling moth damages apples, pears, and some other fruits and is also found in walnuts.

To kill the codling moth if present in walnuts, scientists use safe yet higher-than-normal doses of the regular walnut fumigant methyl bromide in a vacuum chamber. That will kill any codling moths that might be hiding in the harvested nuts, says Patrick V. Vail, an entomologist and director of the agency's Horticultural Crops Research Laboratory, Fresno, CA.

"We now have a way to guarantee that unshelled walnuts are free of live codling moths," says Milton T. Ouye, the ARS coordinator for commodity treatments.

Japan recently lifted an import ban against unshelled walnuts from U.S. orchards because of the effectiveness of vacuum fumigation tests at Fresno.

That will give walnut exporters a new market and may give them incentive to invest in costly vacuum equipment, says Ouye, who is based in Beltsville, MD.

To control insects, methyl bromide is routinely applied to shelled and unshelled walnuts with less expensive equipment at normal (atmospheric) pressure. The fumigant is usually applied in lower doses than in the vacuum method.

Fresno scientists found that the higher doses are needed to kill the occasional codling moth larva that is living inside a walnut at harvest time. At this "overwintering" stage of its life, it is twice as resistant to fumigants as at any other time.

The new dosage overpowers the moth's increased tolerance, and the vacuum helps the fumigant penetrate the shell.

Unshelled walnuts have a longer shelf life than shelled nutmeats and would probably be promoted as a consumer product in Japan. Shelled nutmeats, in contrast, are sold primarily to industrial customers, such as bakeries.

After Australia and West Germany, Japan is currently the third largest importer of U.S. shelled walnuts. The 1985 U.S. walnut crop, produced almost entirely in California, was valued at $161 million.—By **Marcia Wood,** ARS.

Patrick V. Vail is at the USDA-ARS Horticultural Crops Research Laboratory, 2021 South Peach Ave., Fresno, CA 93727. ■

U.S. Department of Agriculture
Agricultural Research Service
Rm. 318, B-005, BARC-WEST
Beltsville, MD 20705
Official Business

To stop mailing ☐ or to change your address ☐ send mailing label on this magazine and new address to Agricultural Research, Rm. 318, B-005, BARC-West, Beltsville, MD 20705

Bulk Rate
Postage and Fees Paid
U.S. Department of Agriculture
Permit No. G—95

PATENTS

New Bacterium Fights Pythium Disease of Cucumbers, Peas

A new type of beneficial soil bacterium that can reduce the occurrence of *Pythium* diseases in cucumbers and peas has been patented by Agricultural Research Service scientists. Pythium causes root rot and the condition known as "damping off" in which seeds and seedlings are killed.

The bacterium, designated as SDL-POP-S-1, is *Pseudomonas cepacia*, a species in the genus *Pseudomonas* which includes other proven biocontrol agents.

A new medium exclusively selective for the bacterium *P. cepacia* has also been developed. The medium, PCAT, was used to isolate the bacterium from soil.

For technical information, contact Robert D. Lumsden, USDA-ARS Soilborne Diseases Laboratory, Building 011A, Room 262, Beltsville Agricultural Research Center, Beltsville, MD 20705. *Patent No. 4,588,584, "Medium for the Isolation of* Pseudomonas Cepacia *Biotype From Soil and the Isolated Biotype."* ■

New Sensor Ensures Top Quality Cotton Fiber

The amount and quality of cotton fiber that gins can strip off cotton seeds depend heavily on moisture content. Gin operators have not been able to obtain continuous, accurate cotton moisture measurements while the cotton is going through the machinery.

Now engineers have developed a contact sensor that measures both moisture and fiber packing density instantaneously as cotton is processed. Several of these new sensors could conceivably be attached to a computer to completely automate moisture control in gins.

The sensors fit on the outside of equipment that stores or transports cotton within the ginning plant, so they can be installed without extensive modification.

For technical information, contact Ed Hughs, USDA-ARS Southwestern Cotton Ginning Research Laboratory, P.O. Box 578, Mesilla Park, NM 88047. *Patent Application Serial No. 818,564, "Fluidic Permeability Measurement Bridge."* ■

How To Obtain a License for USDA Patents

A listing of all U.S. Department of Agriculture patents is available on request. If you are interested in applying for a license on a patent or receiving the catalog, write to the Coordinator, National Patent Program, USDA-ARS, Room 401, Bldg. 005, Beltsville, MD 20705.

Copies of existing patents may be purchased from the Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, Washington, DC 20231. Copies of pending patents may be purchased from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. ■